or non-absorbent appliances, we will discuss those modern contrivances that are now so much used in child-bed Nursing, and by women generally.

(To be continued.)

PRACTICAL LESSONS IN ELECTRO-THERAPEUTICS.

By Arthur Harries, M.D.,
and
H. Newman Lawrence, Member Institution Electrical Engineers.

(Continued from page 113.)

THUS we see that by using this law we may find out with accuracy many things which would otherwise be mere guess work. It tells us at a glance that it is quite useless to attempt to pass a C-S of 20 *m.a.* through a patient of normal R (one thousand two hundred ohms) with a battery of five or six cells, whose total E.M.F. cannot exceed twelve volts and is probably not more than eight; on the other hand, supposing the R of the patient to be reduced to, say, two hundred ohms by using one electrode internally, the C*s* (the same number of cells being used) would be dangerously increased.

The total E.M.F. of batteries depends upon (*a*) the E.M.F. of each cell, and (*b*) the way such cells are arranged or connected up.

(*a*) The E.M.F. of each cell is determined by the difference of potentials of the elements used and the character of the excitant, as we have previously shown. *The size of the elements or the size of the cell itself has no influence on the E.M.F.* A cell made in a jar as large as an oyster barrel has no greater E.M.F. than one made in a test tube, if the elements in each case be of the same materials and the excitant similar.

The idea that large cells possess greater E.M.F. than small ones is a very natural one, but it is entirely erroneous, as may easily be proved by experiment.

As shown above, E.M.F. is the factor in current flow which overcomes resistance (R); therefore if a battery of small cells will not overcome the R. of the body or part thereof and pass a current through, it is equally certain that a battery of large cells (provided, of course, that the number of cells used be the same) will, in like manner, fail to pass any current through the same R.

(*b*) To get the maximum E.M.F. from a battery the cells must be arranged or connected up *in series* as shown in Lesson II.

As the total E.M.F. of the battery has to overcome the total R in the circuit, of which the *internal* R of the battery forms a part, the advantage of *low internal* R. is apparent.

The C-S of batteries depends upon (1) the size of the elements, (2) the activity of the excitant, and (3) the manner in which the cells are connected up.

(1) The size of the elements and the portion of their surface in contact with the excitant are the main factors controlling the C-S of a battery. Large cells having large surface area of their elements in contact with the excitant are capable of giving great C-S, and will therefore be more useful than small cells when strong currents are required. (2) The activity of the excitant has also to be taken into consideration, for a weak excitant means slight chemical action, and slight chemical action in a battery means feeble electric current. (3) Cells in series give the maximum E.M.F. and the minimum C-S, because when so connected we have the sum of all the internal R's to work against, and as $\text{C-S} = \frac{\text{the total E}}{\text{the total R}}$ any arrangement of cells which increases the total R by adding to the internal R, weakens the value of C-S. Cells in parallel give the maximum C-S with the minimum E.M.F., because by this arrangement all the positive elements become practically one, as do also all the negative elements, so that we have what is equivalent to one large cell having consequently the E.M.F. of one cell, and an internal R represented by the reciprocal of the sum of the reciprocals of all the cells.

Let us take an example by way of illustration—A battery of five cells, each cell having an E.M.F. of 1·2 volt, and an internal R of one ohm, is used to pass a current through an external R of a half ohm. With the battery arranged in series our equation would be:—

$$\text{C-S} = \frac{\text{E}}{\text{R}} \textit{ i.e.}, \text{ C-S} = \frac{5 \times 1{\cdot}2}{(5 \times 1) + 0{\cdot}5} = \frac{6}{55} = 1{\cdot}08 \text{ ampère.}$$

With the battery arranged in series our equation would be:—

$$\text{C-S} = \frac{1{\cdot}2}{\frac{1}{5} + 0{\cdot}5} = \frac{1{\cdot}2}{0{\cdot}2 + 0{\cdot}5} = \frac{1{\cdot}2}{0{\cdot}7} = 1{\cdot}71 \text{ ampère.}$$

In this case, then, we have a C-S more than fifty per cent. greater when the cells are arranged in parallel than when they are arranged in series. But we must call attention to the fact that in this example the R of external circuit is very low, and that in practice it frequently happens that owing to the great external R five cells arranged in parallel would not possess sufficient E.M.F. to pass any current at all. The student might with advantage try a few similar examples for himself.

(To be continued.)

No man ever lived a right life who had not been chastened by a woman's love, strengthened by her courage, and guided by her discretion.